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(54) **MATING COAXIAL CONNECTORS HAVING ANTI-ROTATIONAL FEATURES**

(71) Applicant: **DAI-ICHI SEIKO CO., LTD.**, Kyoto (JP)

(72) Inventors: **Yoshimitsu Hashimoto**, Fukuoka (JP); **Shogo Jinnouchi**, Fukuoka (JP)

(73) Assignee: **DAI-ICHI SEIKO CO., LTD.**, Kyoto (JP)

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(51) **Int. Cl.**

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H01R 13/629	(2006.01)
H01R 24/58	(2011.01)
H01R 13/631	(2006.01)
H01R 24/86	(2011.01)

(52) **U.S. Cl.**

CPC ***H01R 13/629*** (2013.01); ***H01R 13/631*** (2013.01); ***H01R 24/58*** (2013.01); ***H01R 24/86*** (2013.01)

(58) **Field of Classification Search**

CPC H01R 24/38; H01R 24/58; H01R 13/6277; H01R 9/05

USPC 439/380, 332, 378, 578, 675

See application file for complete search history.

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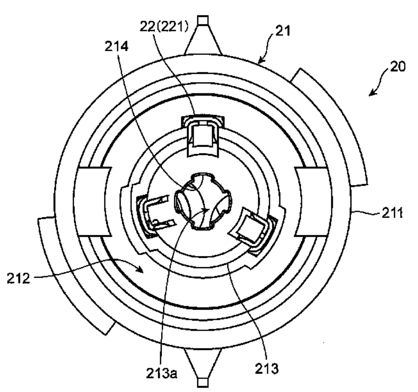
Primary Examiner — Vanessa Girardi

(74) *Attorney, Agent, or Firm* — Wenderoth, Lind & Ponack, L.L.P.

(57) **ABSTRACT**

An electric connector includes a first housing including a guide shaft and a second housing including a guide hole into which the guide shaft is inserted. The guide shaft includes a main body, and a projection radially projecting from the main body, the guide hole being formed at an inner surface thereof with a groove into which the projection is fit. The projection and the groove are formed such that a first imaginary line intersects with a second imaginary line, the first imaginary line being defined by extending a contact plane at which the projection and the groove make contact with each other when the first housing rotates relative to the second housing, towards a center of the main body. The second imaginary line is defined as a line bisecting a top surface of the projection and extending towards a center of the main body.

11 Claims, 16 Drawing Sheets



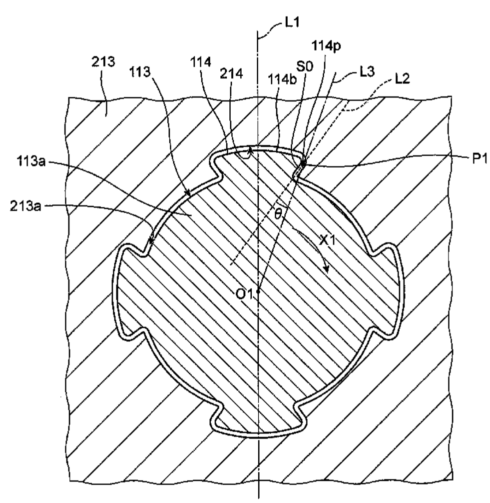
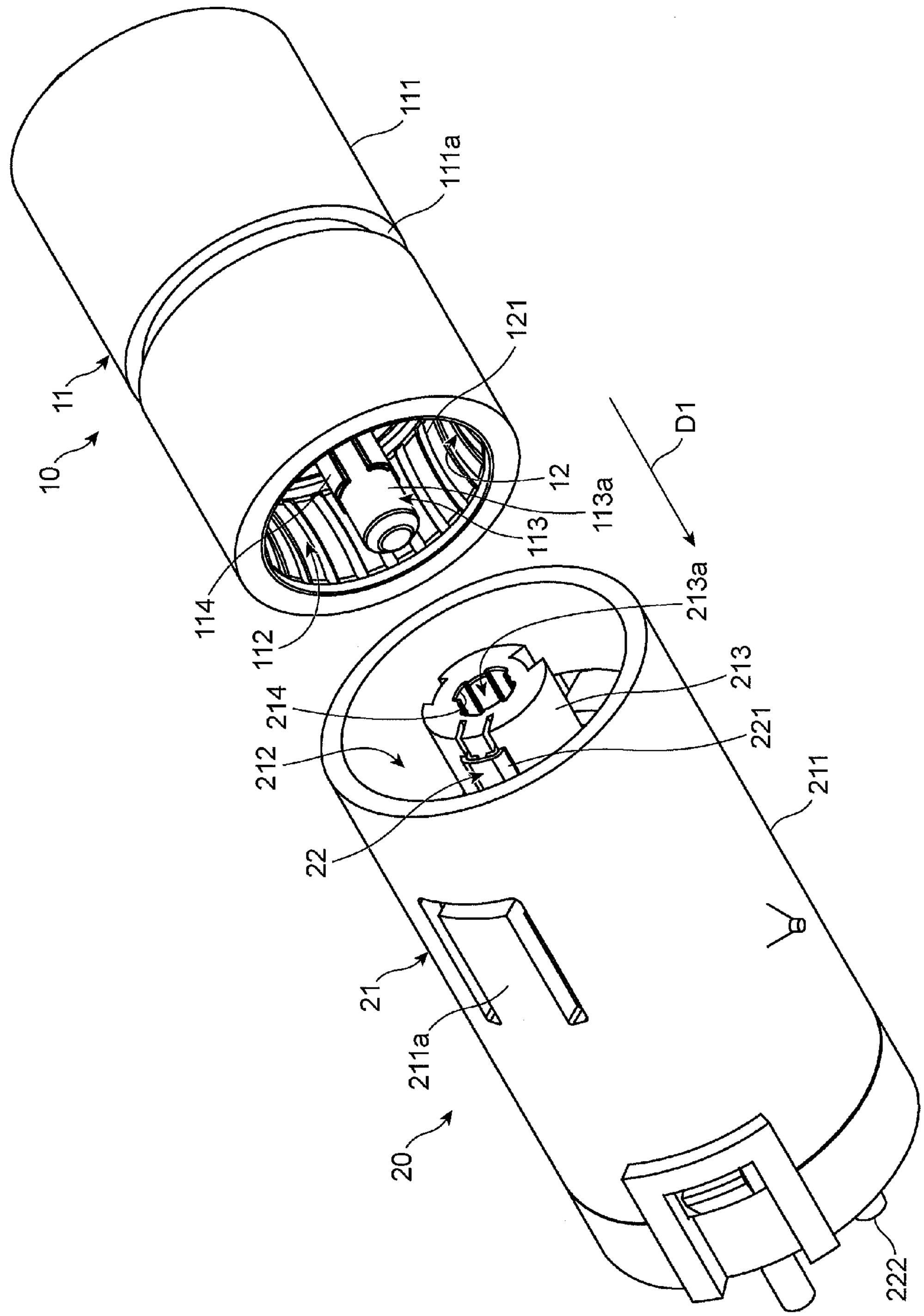


FIG. 1



10
11
111
111a
121
12
113a
113
114
112
D1
213a
213
214
221
212
211
22
21
211a
20
222

FIG. 2

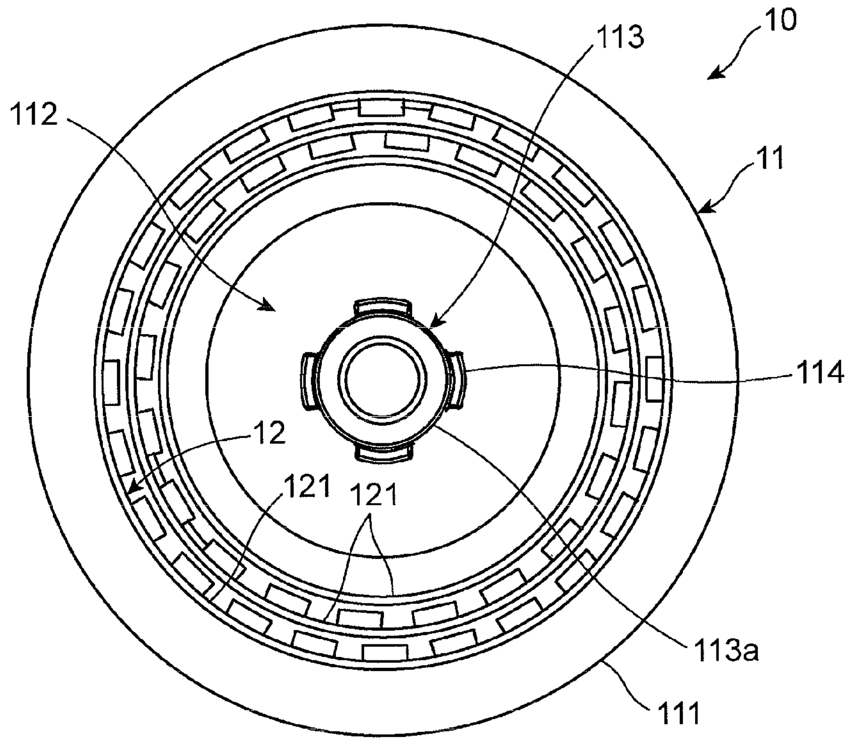


FIG. 3

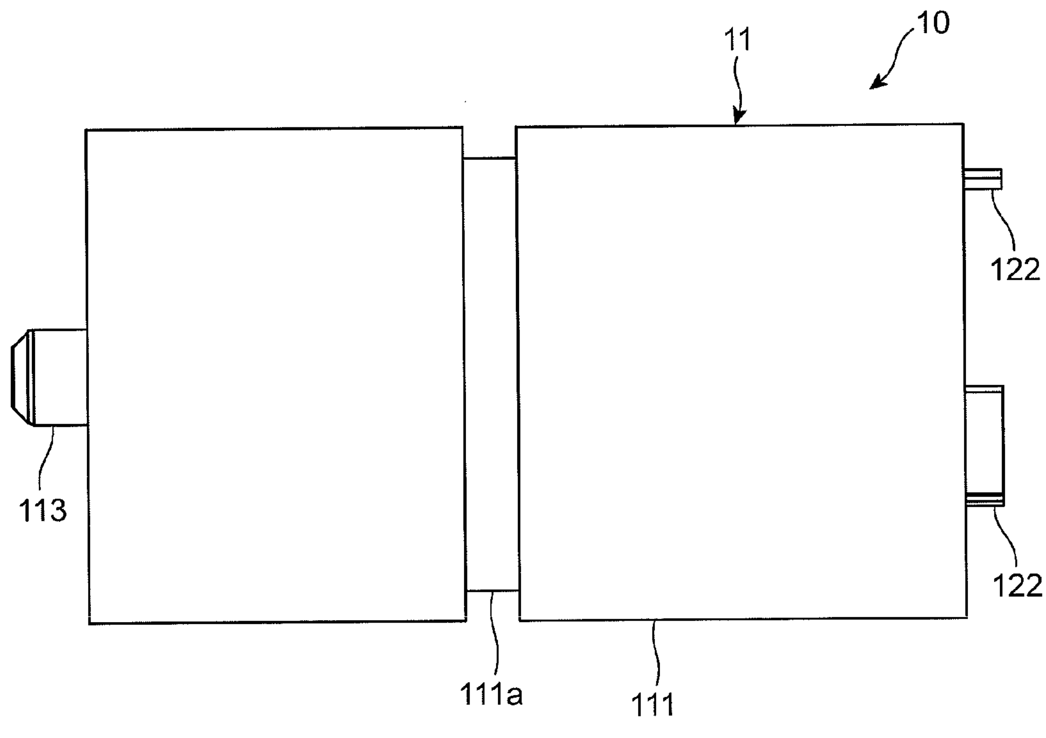


FIG. 4

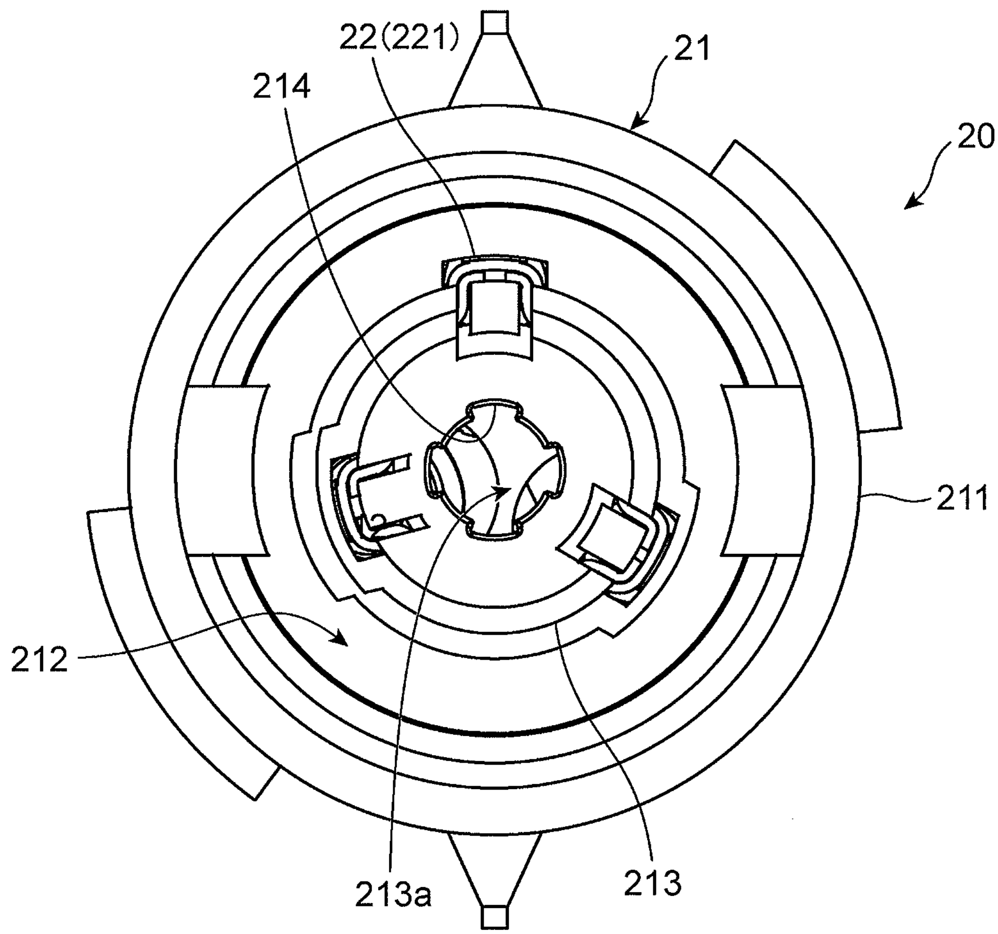


FIG. 5

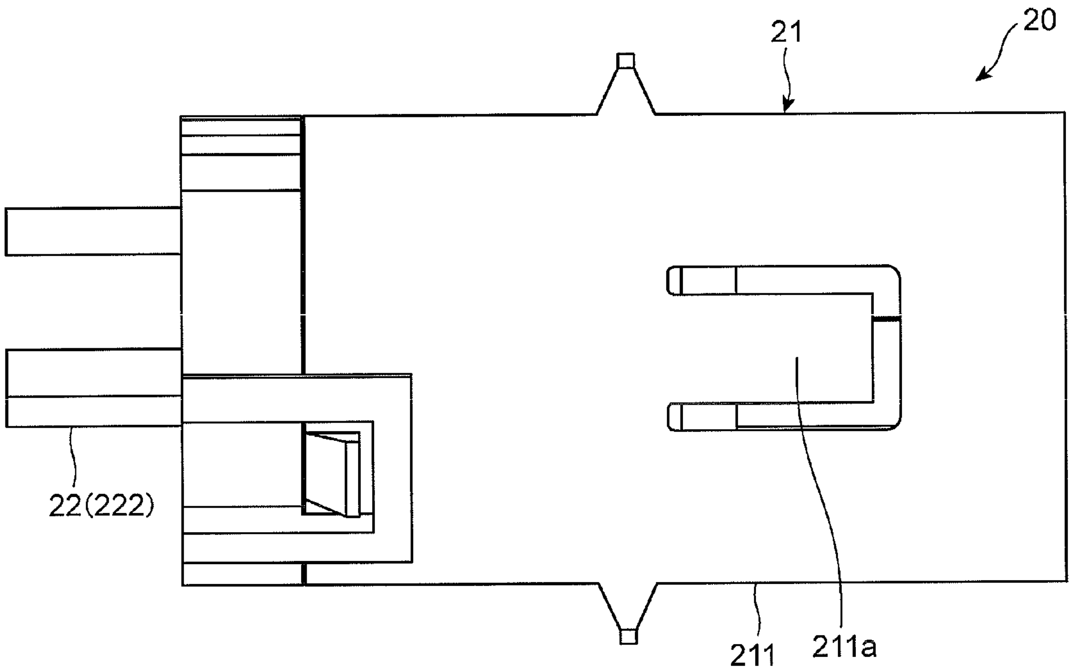


FIG. 6

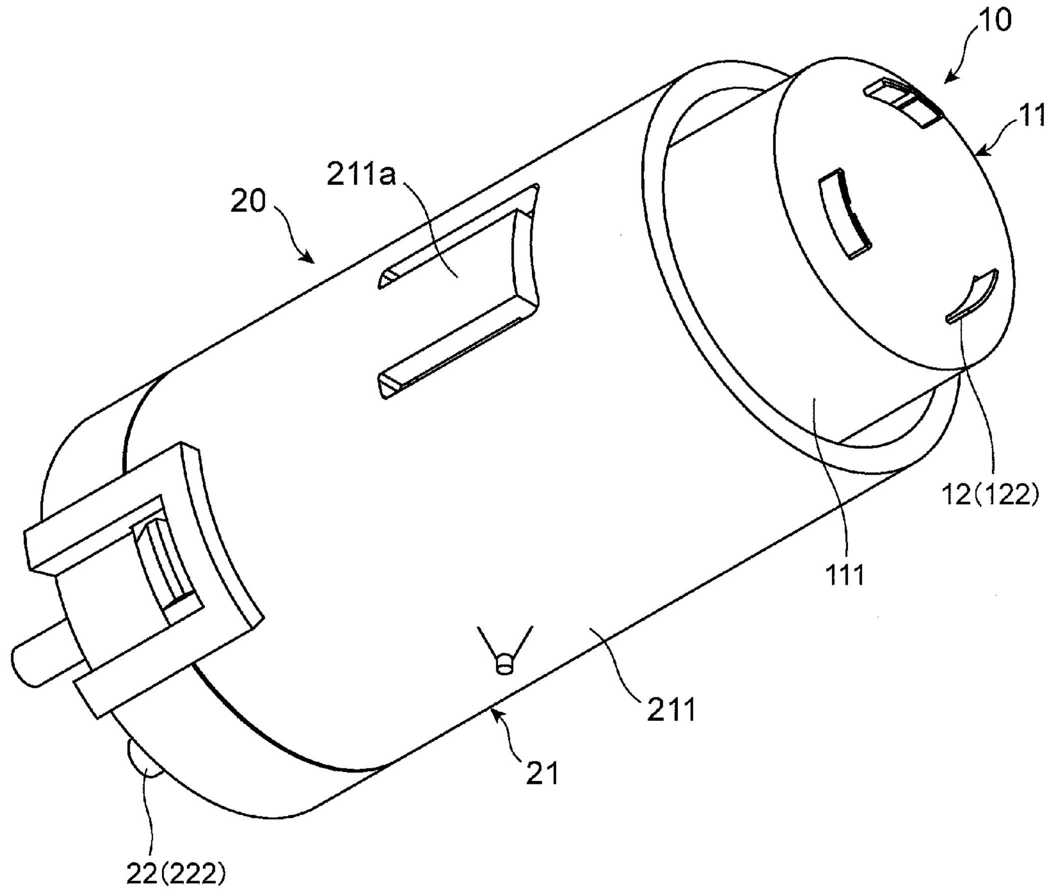


FIG. 7

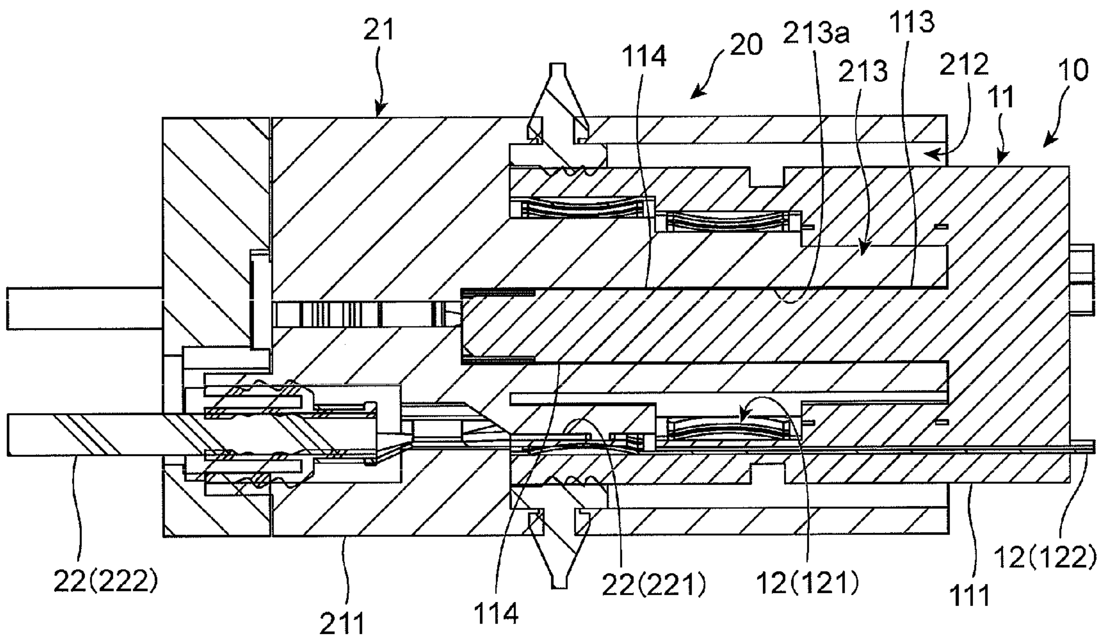

21
114
20
213a
113
213
212
11
10
22(222)
211
114
22(221)
12(121)
111
12(122)

FIG. 8

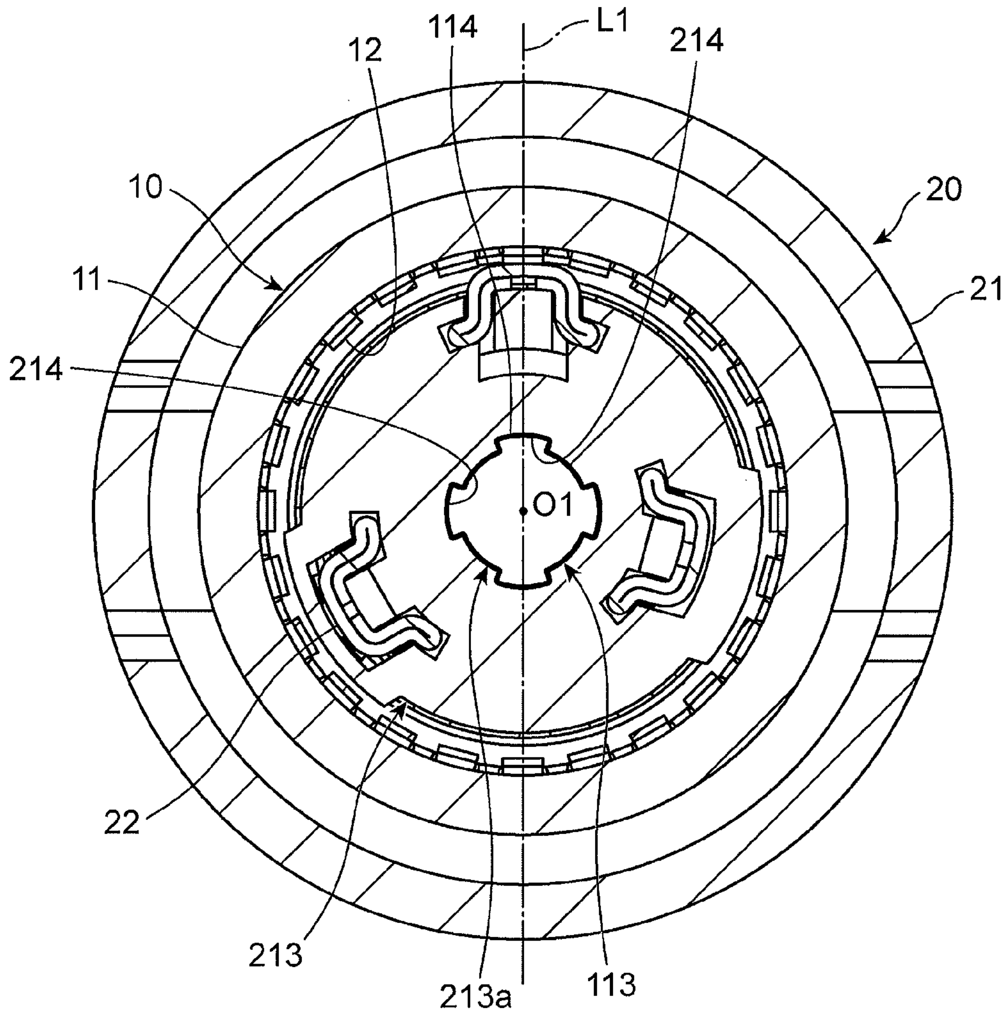


FIG. 9

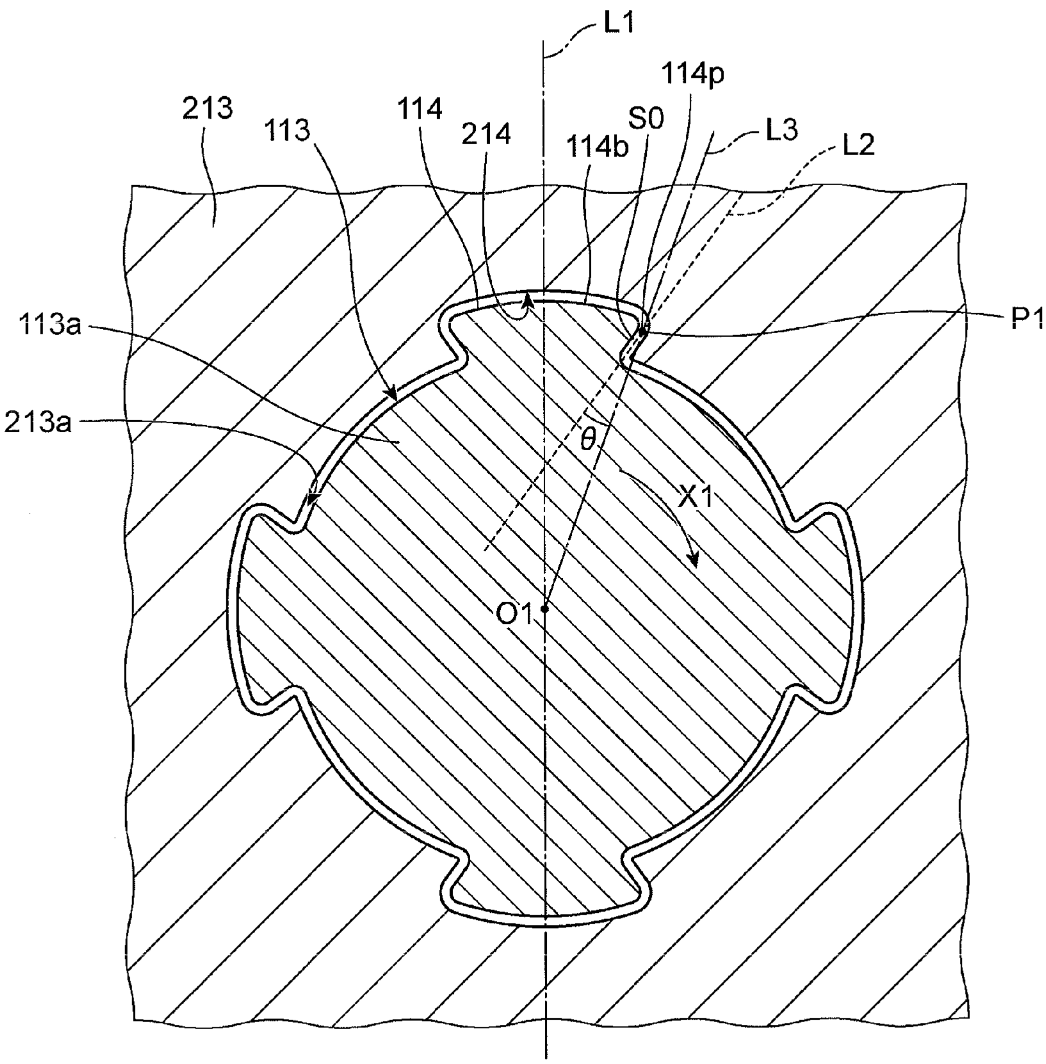


FIG. 10

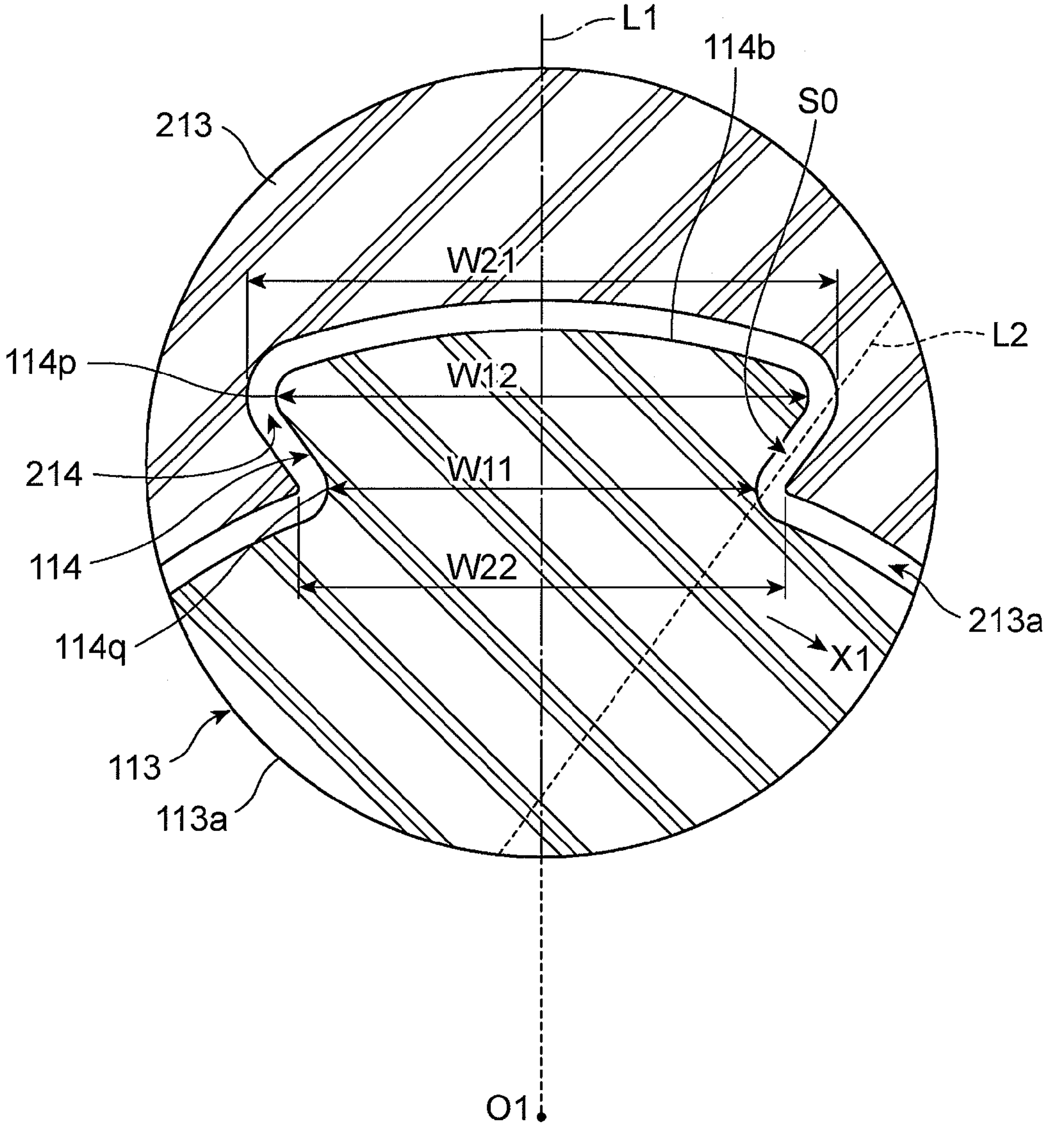
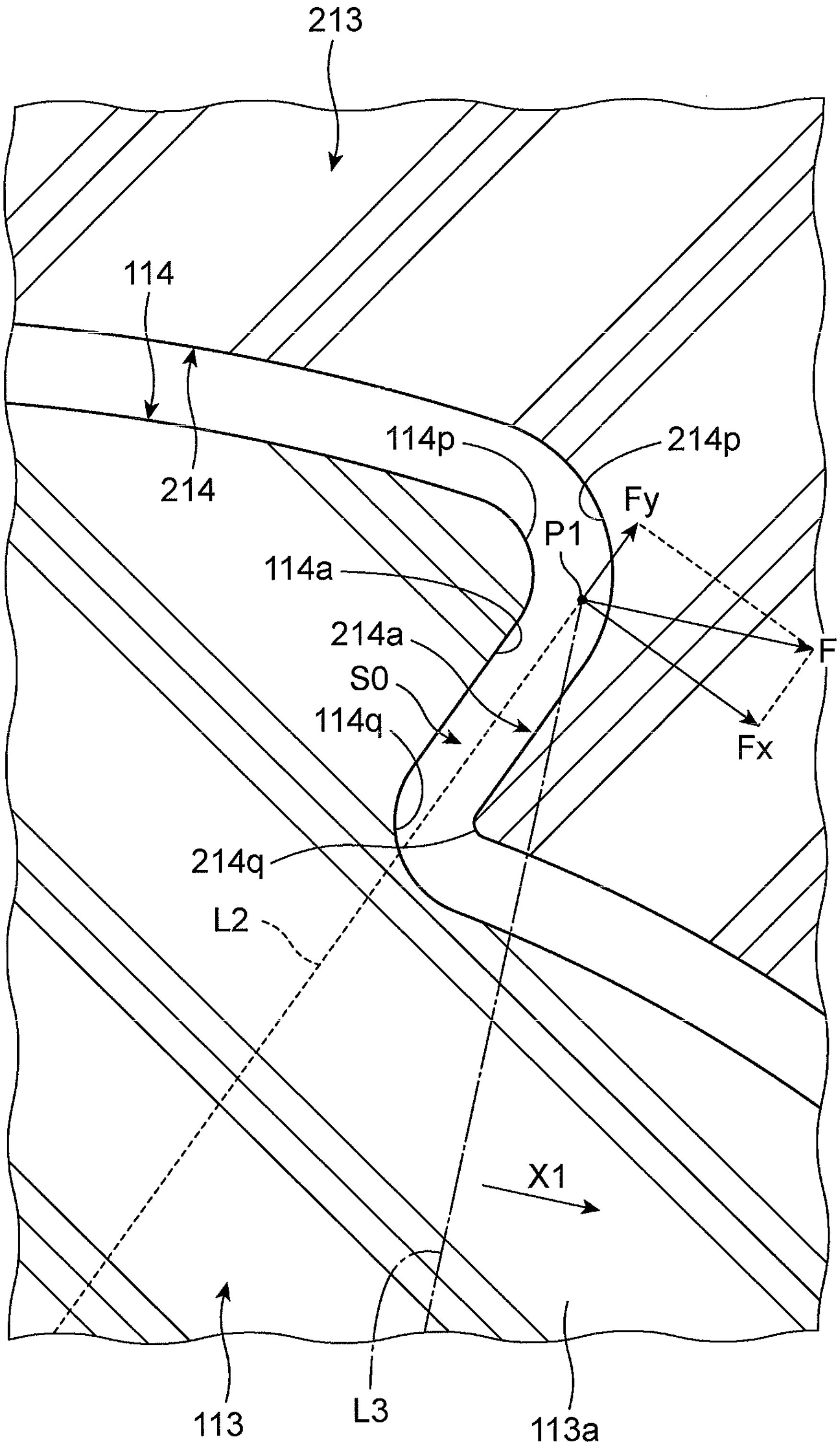

L1
114b
S0
213
W21
L2
114p
W12
214
W11
114
W22
213a
114q
X1
113
113a
O1

FIG. 11


213
114
214
114p
214p
Fy
P1
114a
214a
F
S0
114q
Fx
214q
L2
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113
L3
113a

FIG. 12

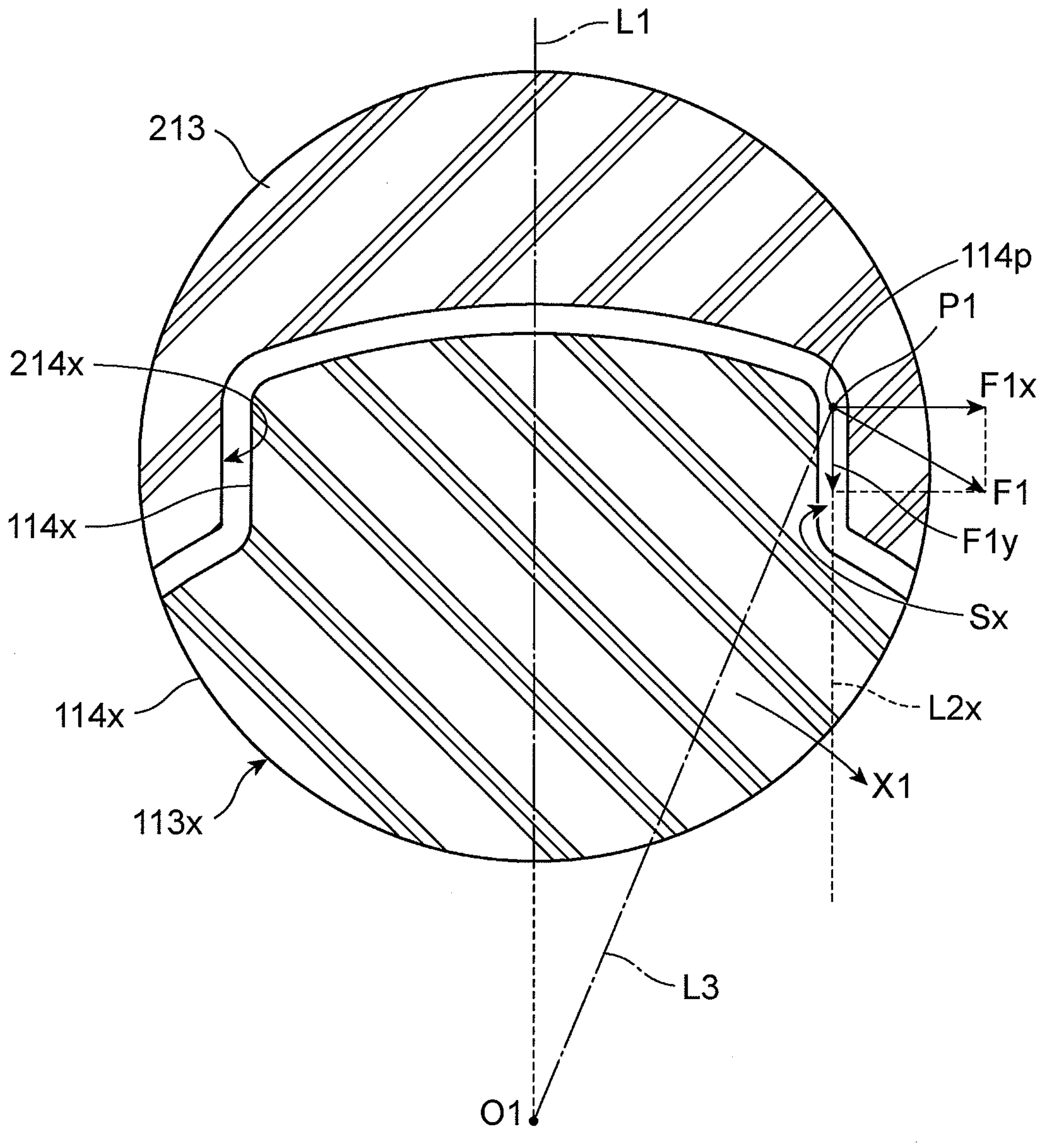


FIG. 13

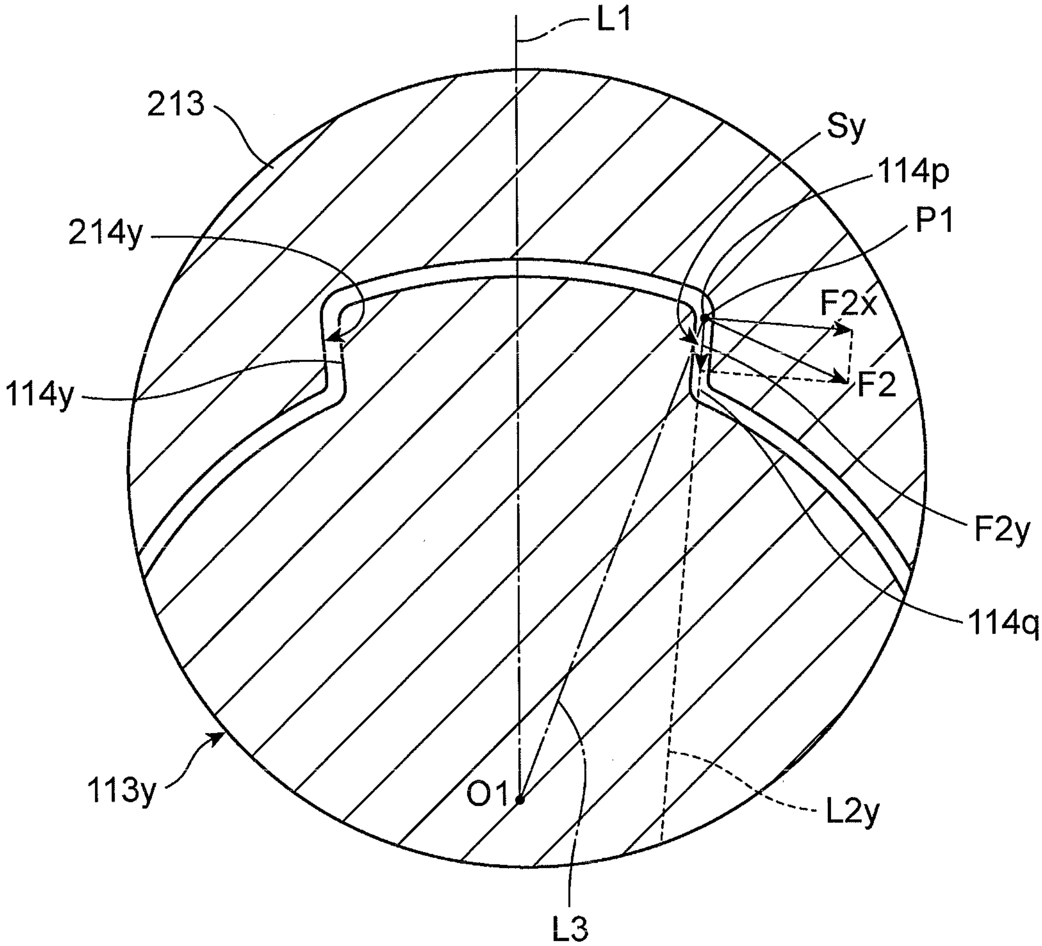


FIG. 14

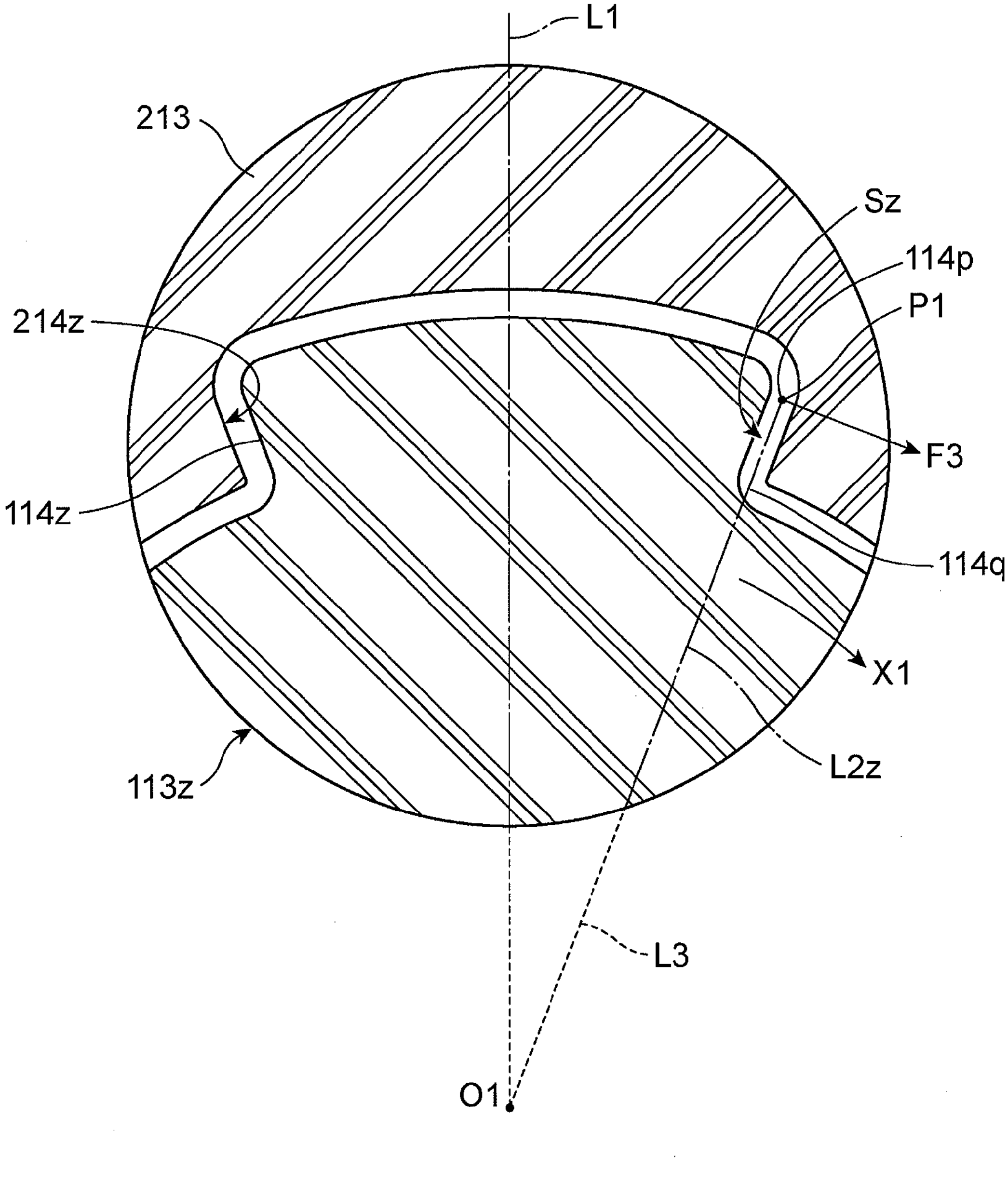


FIG. 15 PRIOR ART

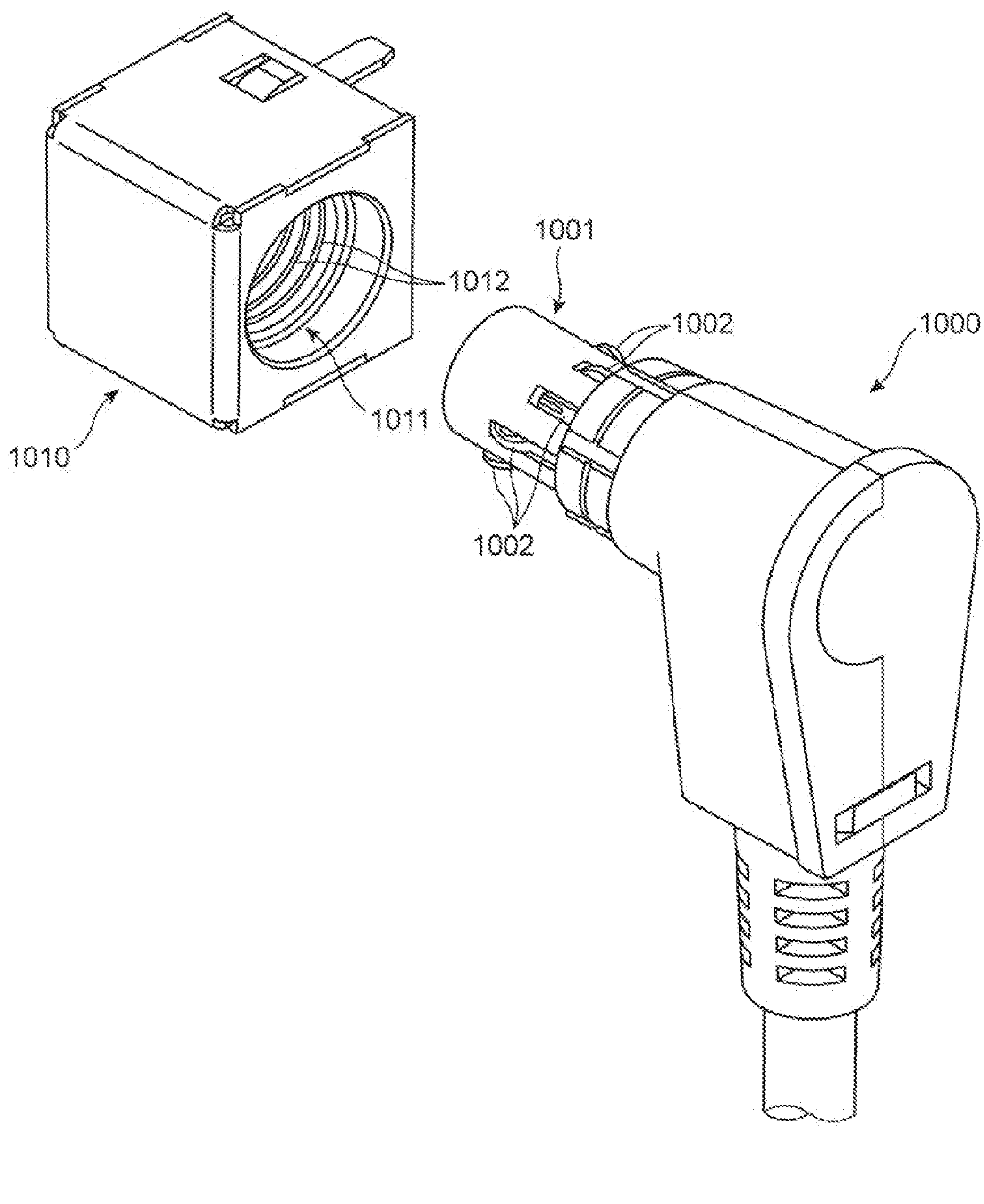


FIG. 16 PRIOR ART

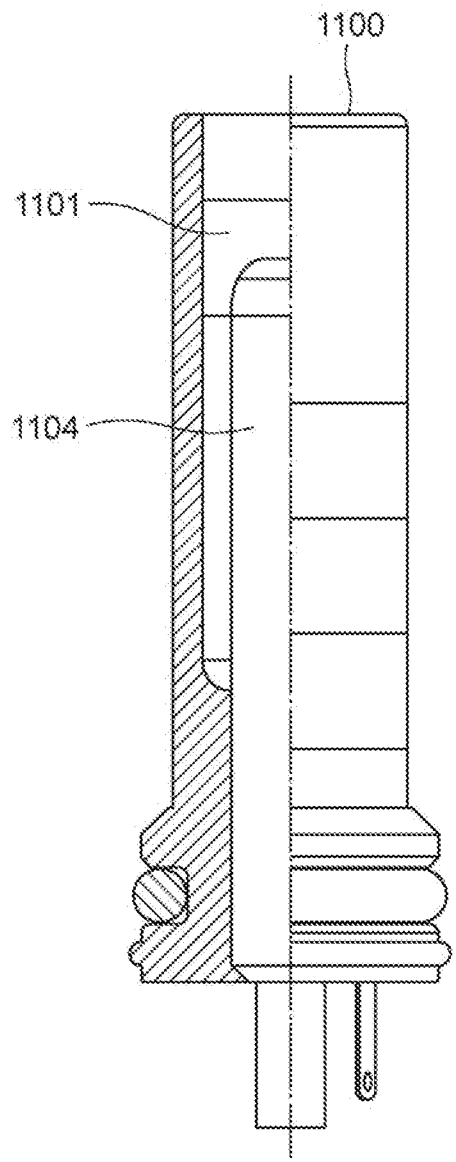
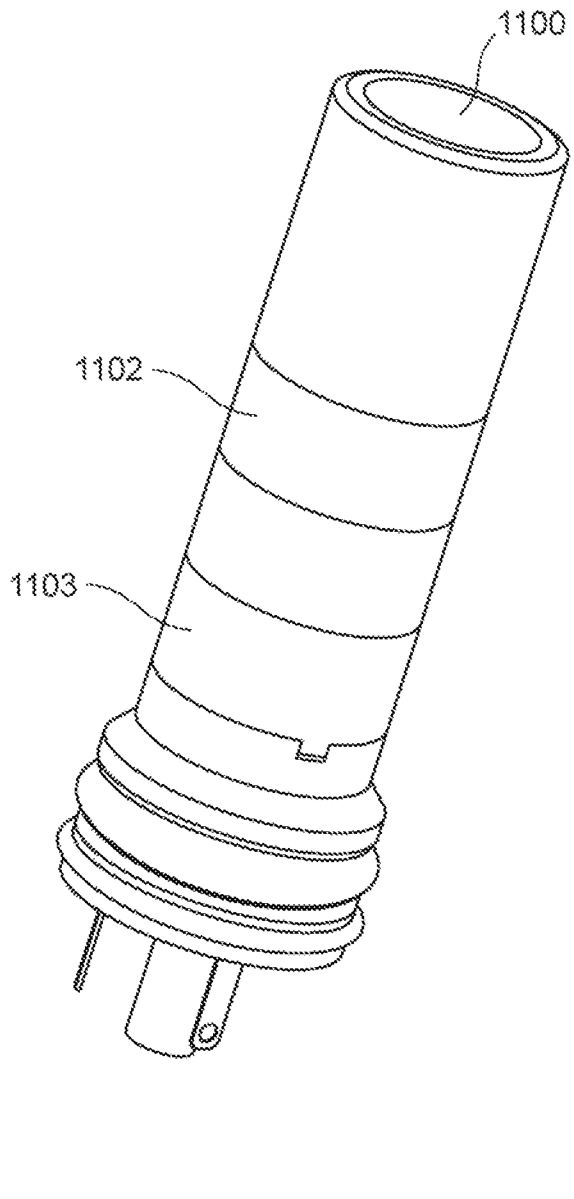


FIG. 17 PRIOR ART



MATING COAXIAL CONNECTORS HAVING ANTI-ROTATIONAL FEATURES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to an electric connector including a first housing of a male connector, and a second housing of a female connector into which the first housing is fit.

2. Description of the Related Art

An electric connector, such as a connector used for a glow plug igniting and/or pre-heating an engine and a connector connecting a combustion-pressure sensor and a wire harness to each other, generally includes a cylindrical male connector. Since the male connector is designed to be symmetrical in rotation relative to a female connector, the male connector can be fit into the female connector even if the male connector is rotated in any direction around an axis of the male connector. Thus, the male connector can be readily fit into the female connector even manually, even if those connectors are located at a place where an operator cannot see the connectors.

FIG. **15** illustrates the electric connector suggested in Japanese Patent Application Publication No. H9 (1997)-35825.

The illustrated electric connector includes a plug connector **1000** and a receptacle connector **1010**. The plug connector **1000** includes a plug insulator **1001** having a rotation-symmetry shape, and a plurality of contacts **1002** each situated at different distances from a distal end of the plug insulator **1001**. The receptacle connector **1010** is formed with a hole **1011** into which the plug connector **1000** can be inserted. When the receptacle connector **1010** is fit into the hole **1011**, contacts **1012** face an inner surface of the hole **1011**.

FIG. **16** is a cross-sectional view of the glow plug suggested in Japanese Patent Application Publication No. 2005-207730, and FIG. **17** is a perspective view of the glow plug.

The illustrated glow plug includes an electrically insulated casing **1100**, sensor terminals **1101** to **1103** arranged outside and inside of the casing **1100**, and a connector **1104**. The sensor terminals **1101** to **1103** make electrical contact with sensor-connectors of a sensor (not illustrated) of a connector (not illustrated) when the glow plug is fit into the connector. The connector **1104** is electrically connected to a terminal of a heater of the glow plug when the glow plug is fit into the connector.

The conventional electric connectors illustrated in FIGS. **15** to **17** have an advantage that a male connector can be fit into a female connector even if the male connector is axially rotated in any direction. However, the conventional electric connectors are accompanied with a problem that if they are oscillated or they receive impact when a male connector is fit into a female connector, one of the connectors is forced to axially rotate, resulting in that the one of the connectors gradually retreats, and thus, the male connector might be released from the female connector. The male and female connectors may be formed with a projection and a recess into which the projection can be fit, respectively, in order to prevent the male and female connectors from axially rotating. However, if an intensive force acts on the male and female connectors in a direction of the axial rotation, the projection would be collapsed, resulting in that one of the male and female connectors makes relative axial rotation. Thus, the conventional electric connectors are accompanied with a problem of deterioration in reliability to electrical connection between the male and female connectors.

SUMMARY OF THE INVENTION

In view of the above-mentioned problems in the conventional electric connectors, it is an object of the present invention to provide an electric connector capable of having an increased proof stress to axial rotation to thereby enhance reliability to electrical connection between male and female connectors.

In one aspect of the present invention, an electric connector includes a first housing including a guide shaft, and a second housing including a guide hole into which the guide shaft is inserted. The guide shaft includes a main body, and at least one projection radially projects from the main body. The guide hole is formed at an inner surface thereof with at least one groove into which the projection is fit, and the projection and the groove are formed such that a first imaginary line intersects with a second imaginary line. The first imaginary line is defined by extending a contact plane at which the projection and the groove make contact with each other when the first housing rotates relative to the second housing, towards a center of the main body, and the second imaginary line is defined as a line bisecting a top surface of the projection and extending towards a center of the main body.

In the electric connector in accordance with the present invention, the first imaginary line is designed to intersect with the second imaginary line. Thus, the projection has a surface inclining away from the second imaginary line from a lower end towards an upper end thereof, ensuring that the projection and the groove can be kept to be fit into each other.

In a preferred embodiment, the first imaginary line intersects with the second imaginary line between the projection and the center of the main body.

This embodiment ensures that the projection is hard to be collapsed when one of the housings axially rotates, because the projection bites into the groove.

It is preferable that the first imaginary line intersects with the center of the main body.

It is preferable that the guide shaft includes a plurality of projections, and the guide hole is formed with a plurality of grooves, the projections being equally spaced away from adjacent ones, and the grooves being equally spaced away from adjacent ones.

It is possible to equally disperse a stress exerted by the projection on the groove when the first housing axially rotates.

For instance, the first housing comprises a housing of a male connector, and the second housing comprises a housing of a female connector, in which case, the guide shaft extends in the first housing, and the guide hole is formed along an axis of a shaft extending in the second housing.

When the first housing is inserted into the second housing, even if the first housing is attempted to be inserted in an inclined condition into the second housing, the first housing can be accurately inserted into the second housing by inserting the guide shaft into the guide hole, because the guide shaft is guided along the guide hole. Furthermore, the combination of the projection and the groove prevents the guide shaft from axially rotating when the guide shaft is to be inserted into the guide hole.

It is preferable that the projection has an arcuate top surface, in which case, since the arcuate projection can be thicker at a summit thereof than a flat projection, the projection can have an increased strength.

It is preferable that the first imaginary line and a third imaginary line connecting an outermost end of the projection and the center of the main body with each other form an angle in the range of 10 and 30 degrees both inclusive.

It is preferable that the contact plane and the top surface of the projection form an acute angle.

Another aspect of the present invention relates to a combination of a shaft and a hole into which the shaft can be inserted. The shaft includes a main body, and at least one projection radially projects from the main body. The hole is formed at an inner surface thereof with at least one groove into which the projection is fit, and the projection and the groove are formed such that a first imaginary line intersects with a second imaginary line. The first imaginary line is defined by extending a contact plane at which the projection and the groove make contact with each other when the shaft rotates relative to the hole, towards a center of the main body, and the second imaginary line is defined as a line bisecting a top surface of the projection and extending towards a center of the main body.

The advantages obtained by the aforementioned present invention will be described hereinbelow.

In the electric connector in accordance with the present invention, the projection has a surface inclining away from the second imaginary line from a lower end towards an upper end thereof, ensuring that the projection and the groove can be kept to be fit into each other. Thus, the electric connector in accordance with the present invention can have an increased proof stress or resistance to axial rotation, resulting in enhancement in reliability to electrical connection between the first and second housings.

The above and other objects and advantageous features of the present invention will be made apparent from the following description made with reference to the accompanying drawings, in which like reference characters designate the same or similar parts throughout the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of the electric connector including a male connector and a female connector, in accordance with the preferred embodiment of the present invention.

FIG. **2** is a front view of the male connector.

FIG. **3** is a right side view of the male connector.

FIG. **4** is a front view of the female connector.

FIG. **5** is a left side view of the female connector.

FIG. **6** is a perspective view of the male and female connectors fit into each other.

FIG. **7** is a lateral cross-sectional view of the male and female connectors fit into each other.

FIG. **8** is a longitudinal cross-sectional view of the male and female connectors fit into each other.

FIG. **9** is a partially enlarged view of the guide shaft and the guide hole into which the guide shaft is inserted.

FIG. **10** is a partially enlarged cross-sectional view of the projection and the groove into which the projection is fit.

FIG. **11** is a partially enlarged cross-sectional view of a contact plane at which the projection and the groove make contact with each other.

FIG. **12** is a partially enlarged cross-sectional view of the case in which an imaginary line as an extension of the contact plane does not intersect with an imaginary line bisecting the projection.

FIG. **13** is a partially enlarged cross-sectional view of the case in which an imaginary line as an extension of the contact plane intersects with an imaginary line bisecting the projection, at a location out of an area defined between the projection and a center of the guide shaft.

FIG. **14** is a partially enlarged cross-sectional view of the case in which an imaginary line as an extension of the contact plane intersects with a center of the guide shaft.

FIG. **15** is a perspective view of the conventional electric connector.

FIG. **16** is a partial cross-sectional view of another conventional electric connector.

FIG. **17** is a perspective view of the conventional electric connector illustrated in FIG. **16**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** is a perspective view of the electric connector in accordance with the preferred embodiment of the present invention.

As illustrated in FIG. **1**, the electric connector includes a male connector **10** and a female connector **20**.

The male connector **10** and the female connector **20** are used for connecting various kinds of sensors to a wire harness, for instance.

First, the male connector **10** is explained hereinbelow.

As illustrated in FIGS. **1** to **3**, the male connector **10** includes a male housing **11** to be fit into the female connector **20**, and three male contact terminals **12** electrically connecting the male connector **10** to the female connector **20**.

The male housing **11** includes a cylindrical main body **111** open at one end and closed at the other end to thereby define a hollow space **112** therein, and a guide shaft **113** extending in the hollow space **112** in a direction D**1** in which the male connector **10** is fit into the female connector **20**.

The main body **111** is formed at a center in a length-wise direction and circumferentially thereof with an annular groove **111***a*. The hollow space **112** has three cylindrical inner areas. As illustrated in FIG. **7**, the inner area located nearer to a bottom of the housing **11** is designed to have a smaller inner diameter.

The guide shaft **113** has a main body **13***a* with a circular cross-section, and is coaxial with the hollow space **112**. As illustrated in FIG. **2**, the guide shaft **113** is formed at an outer surface thereof and circumferentially around an axis thereof with four projections **114** equally spaced apart from each other. Specifically, the projections **114** are located at every 90 degrees around the central longitudinal axis of the guide shaft **113**. Each of the projections **114** has a length starting from a location away from a top end of the guide shaft **113** and extending in a direction opposite to the direction D**1**. The guide shaft **113** outwardly extends beyond the male housing **11**, as illustrated in FIG. **3**.

Each of the three male contact terminals **12** makes mechanical and electrical contact with a later-mentioned female contact terminal. In line with the hollow space **112** having the three inner areas having inner diameters different from one another, each of the male contact terminals **12** includes a cylindrical contact **121** having an inner diameter different from the same of the other cylindrical contacts, and a connector **122** (see FIG. **3**) extending outwardly of the male housing **11** from an end of the contact **121**. Each of the contacts **122** is connected to a cable (not illustrated).

The female connector **20** is explained hereinbelow.

As illustrated in FIGS. **1**, **4** and **5**, the female connector **20** includes a female housing **21** into which the male housing **11** is fit, and three female contact terminals **22** electrically connecting the female connector **20** to the male connector **10**.

The female housing **21** includes a cylindrical main body **211** open at an end and closed at the other end to define a hollow space **212** therein, and a shaft **213** extending in a direction opposite to the direction D**1**.

As illustrated in FIG. **1**, the main body **211** is formed with an engagement hook **211***a* to be engaged with the groove **111***a* when the male housing **11** is inserted into the hollow space **212** of the female housing **21**.

The shaft **213** is cylindrical and coaxial with the hollow space **212**. The shaft **213** is formed with a guide hole **213***a* extending along an axis of the shaft **213**. As illustrated in FIG. **4**, the guide hole **213***a* is formed at an inner surface thereof with four grooves **214** circumferentially equally spaced apart from each other around an axis of the shaft **213**. Specifically, the grooves **214** are formed at an inner surface of the guide hole **213***a* at every 90 degrees around an axis of the shaft **213** corresponding to the projections **114**.

The female contact terminal **22** is comprised of a linear terminal designed to make mechanical and electrical contact with the male contact terminal **12**. As illustrated in FIG. **4**, the female contact terminals **22** are situated on an outer surface of the shaft **213** at different distances around an axis of the shaft **213**. Each of the three female contact terminals **22** makes mechanical and electrical contact with each of the three male contact terminals **12**. Each of the female contact terminals **22** includes a contact **221** situated on an outer surface of the shaft **213** and having a substantially U-shaped cross-section, and a connector **222** extending outwardly of the female housing **21** from a rear end of the contact **221** (see FIG. **5**). The connector **222** is connected to a cable (not illustrated).

As illustrated in FIGS. **1** and **6** to **8**, when the male connector **10** is fit into the female connector **20**, the main body **111** of the male connector **20** is inserted into the hollow space **212** of the female housing **21**, the shaft **213** of the female connector **20** is inserted into the hollow space **112** of the male housing **11**, and the guide shaft **113** is inserted into the guide hole **213***a*. Concurrently, the contacts **121** of the male contact terminals **12** make mechanical and electrical contact with the contacts **221** of the female contact terminals **22**.

When the male connector **10** is inserted into the female connector **20**, even if the male connector **10** is attempted to be inserted in an inclined condition into the female connector **20**, it is possible to insert the male connector **10** in an accurate position into the female connector **20**, because the guide shaft **113** is inserted into the guide hole **213***a* of the shaft **213**. Thus, the male connector **10** can be inserted into the female connector **20** with axes thereof being coincident with each other, ensuring it possible to prevent the male connector **10** inclining relative to an axis thereof from being inserted into the female connector **20**, and the male connector **10** from being thrust into the female connector **20**.

Accordingly, the male connector **10** can be fit into the female connector **20** without damaging the male contact terminals **12** and/or the female contact terminals **22**, ensuring enhancement in reliability to the electrical connection between the male connector **10** and the female connector **20**.

Furthermore, since the projections **114** are formed on an outer surface of the guide shaft **113**, and the grooves **214** are formed on an inner surface of the guide hole **213***a* of the shaft **213**, as illustrated in FIG. **1**, it is possible to prevent the guide shaft **113** from axially rotating, that is, rotating around an axis of the male housing **11**, when the guide shaft **113** is inserted into the guide hole **213***a* of the shaft **213**. Accordingly, it is possible to prevent the male contact terminals **12** and the female contact terminals **22** from rubbing each other due to the axial rotation of the male connector **10** and/or the female connector **20**, and further, to avoid the male contact terminals **12** and the female contact terminals **22** from being damaged, ensuring further enhancement in reliability to the electrical connection between the male connector **10** and the female connector **20**.

Furthermore, since the projections **114** are formed at a position away from a top end of the guide shaft **113**, the projections **114** do not interfere with the guide hole **213***a* when the guide shaft **113** is inserted into the guide hole **213***a* of the shaft **213**. Thus, the guide shaft **113** can be aligned with the guide hole **213***a*, ensuring that the guide shaft **213** can be smoothly inserted into the guide hole **213***a*.

The positional relation between the projection **114** and the groove **214** is explained hereinbelow with reference to FIGS. **8** to **13**. It should be noted that FIGS. **9** to **13** illustrate a big gap in exaggeration between the projection **114** and the groove **214**, but the actual gap is quite small. Namely, the projection **114** and the groove **214** make partial contact with each other.

As illustrated in FIGS. **8** and **9**, the projection **114** and the groove **214** are located in line-symmetry with each other about a second imaginary line L**1** (defined as a second imaginary line in claims) in a plane perpendicular to an axis of the guide shaft **113**. Herein, the second imaginary line L**1** is defined as a line extending radially of (diametrically across) the guide hole **213***a* (or the guide shaft **113**) and passing through a center O**1** of the axes of the guide shaft **113** and the shaft **213**. Thus, the imaginary line L**1** is coincident with an imaginary line bisecting a top (outer) surface **114***b* of the projection **114** and extending towards the center O**1**, and further coincident with a line perpendicularly bisecting either a line extending between opposite upper ends **114***p* of the projection **114** (see FIG. **10**) or a line extending between opposite lower ends **114***q* of the projection **114** (see FIG. **10**).

As illustrated in FIG. **10**, a width W**11** between the opposite lower ends **114***q* is designed smaller than a width W**12** between the opposite upper ends **114***p* in the projection **114**. A width W**22** of an entrance to the groove **214** is greater than a width **21** of a bottom of the groove **214**.

By designing the projection **114** and the groove **214** in the above-mentioned manner, as illustrated in FIG. **9**, a first imaginary line L**2** (defined as a first imaginary line in claims) intersects with the second imaginary line L**1**. Herein, the first imaginary line L**2** is defined as a line extending from a contact plane S**0** (a plane at which a sidewall **114***a* of the projection **114** (see FIG. **11**) and a sidewall **214***a* of the groove **214** make contact with each other) located in a direction X**1** of the axial rotation of the guide shaft **113**, towards the center O**1**. Specifically, the first imaginary line L**2** intersects the imaginary line L**1** between the projection **114** and the center O**1**, as illustrated in FIG. **9**.

For instance, it is supposed that, as illustrated in FIG. **12**, the imaginary line L**2***x* defined as a line extending from the contact plane Sx towards the center O**1** is in parallel with the second imaginary line L**1** bisecting the projection **114***x*, and hence, does not intersect with the second imaginary line L**1**.

In the structure illustrated in FIG. **12**, when the guide shaft **113***x* rotates, the vector F**1** acting on the contact plane Sx at an outermost end P**1** (an upper end **114***p*) in the direction X**1** directs perpendicularly to an imaginary line L**3** connecting the outermost end P**1** of the contact surface Sx and the center O**1** to each other. The vector F**1** can be divided into a vector F**1***x* indicating a force perpendicularly acting on the contact plane Sx, and a vector F**1***y* indicating a force directing radially and inwardly of the guide shaft **113***x* along the imaginary line L**2***x*.

Since the vector F**1***y* facilitates the projection **114***x* to be released out of the groove **214***x*, the projection **114***x* can be readily collapsed, and is readily released out of the groove **214***x*. Consequently, the projection **114***x* is collapsed due to the axially rotational force, resulting in that the guide shaft **113***x* rotates in idle.

It is supposed that, as illustrated in FIG. **13**, the imaginary line L**2***y* defined as a line extending from the contact plane Sy towards the center O**1** intersects with the imaginary line L**1** bisecting the projection **114***y*, at a location out of an area extensive between the projection **114**y and the center O**1** (the intersection location is not illustrated in FIG. **13**).

In the structure illustrated in FIG. **13**, when the guide shaft **113**y rotates, the vector F**2** acting on the contact plane Sy at an outermost end P**1** in the direction X**1** directs perpendicularly to the imaginary line L**3** connecting the outermost end P**1** of the contact surface Sy and the center O**1** to each other. The vector F**2** can be divided into a vector F**2**x indicating a force perpendicularly acting on the contact plane Sy, and a vector F**2**y indicating a force directing radially and inwardly of the guide shaft **113**y along the imaginary line L**2**y.

Similarly to the vector F**1**y illustrated in FIG. **12**, the vector F**2**y facilitates the projection **114**x to be released out of the groove **214**x. However, as illustrated in FIG. **13**, since the contact plane Sy is defined such that the imaginary line L**2**y intersects with the imaginary line L**1**, the vector F**2**y is smaller than the vector F**2**x illustrated in FIG. **12**.

Furthermore, since the contact plane Sy inclines away from the imaginary line L**1** in a direction towards the upper ends **114**p from the lower ends **114**q, the contact plane Sy can be inclined to a greater degree than the contact plane Sx illustrated in FIG. **12**. Accordingly, if the projection **114**x illustrated in FIG. **12** has a height equal to the same of the projection **114**y illustrated in FIG. **13**, the contact plane Sy can have a greater area than an area of the contact plane Sx. Thus, the projection **114**y and the groove **214**y both illustrated in FIG. **13** can be more firmly engaged to each other than those illustrated in FIG. **12**.

It is supposed that, as illustrated in FIG. **14**, the imaginary line L**2**z defined as a line extending from the contact plane Sz towards the center O**1** intersects with the imaginary line L**1**, at the center O**1**.

In the structure illustrated in FIG. **14**, when the guide shaft **113**z rotates, the vector F**3** acting on the contact plane Sz at an outermost end P**1** (an upper end **114**p) in the direction X**1** directs perpendicularly to the imaginary line L**3** connecting the outermost end P**1** of the contact surface Sz and the center O**1** to each other. The vector F**3** is comprised only of a force acting perpendicularly on the contact plane Sz. Accordingly, the vector F**3** acting on the contact plane Sz in the direction X**1** and the force acting on the contact plane Sz direct in the same direction, or the vector F**3** and the force are identical with each other as a vector. Hence, a divided force along the contact plane Sz is not generated. Thus, it is possible to make it difficult for the projection **114**z to be released out of the groove **214**z.

As explained above, by designing the contact plane Sz such that the imaginary line L**2** intersects with the center O**1** on which the imaginary line L**1** passes, the structure illustrated in FIG. **14** can keep the projection **114**z and the groove **214**z engaged to each other more firmly than the structure illustrated in FIG. **13**.

In FIG. **9**, the contact surface S**0** is designed such that the imaginary line L**2** intersects with the imaginary line L**1** between the projection **114** and the center O**1**. The vector F acting on the contact plane S**0** at the outermost end P**1** (the upper end **114**p) in the direction X**1**, indicative of a force acting on the contact plane S**0** when the guide shaft **113** axially rotates relative to the shaft **213**, directs perpendicularly to the imaginary line L**3** connecting the outermost end P**1** and the center O**1** to each other, as illustrated in FIGS. **9** and **11**. The vector F can be divided into a vector Fx directing perpendicularly to the imaginary line L**2**, and a vector Fy directing radially and outwardly of the guide shaft **113** along the imaginary line L**2**.

Thus, the vector Fx acts as a force acting perpendicularly on the contact plane S**0**, and the vector Fy acts as a force pushing and compressing the projection **114** onto a corner defined by a sidewall and a bottom of the groove **214**.

By designing the contact surface S**0** such that the imaginary line L**2** intersects with the imaginary line L**1** between the projection **114** and the center O**1**, as illustrated in FIG. **9**, the projection **114** makes action of intruding on the groove **214** even if the guide shaft **113** attempts to axially rotate, the projection **114** is hard to be collapsed, and further, it is possible to keep the projection **114** and the groove **214** firmly engaged to each other. Since the guide shaft **113** is surely in mesh with the shaft **213**, the male contact terminals **12** and the female contact terminals **22** can keep in contact with each other. Hence, the stable electrical connection can be accomplished between the male connector **10** and the female connector **20**. Thus, the male connector **10** and the female connector **20** in the electric connector in accordance with the first embodiment can have an increased proof stress or resistance in the direction of the axial rotation, ensuring enhancement in reliability to the electrical connection between the male connector **10** and the female connector **20**.

By designing the projection **114** to have a greater height or designing the groove **214** to have a greater depth, the projection **114** and the groove **214** can be more intensively in mesh with each other, and the projection **114** can be prevented from collapsing even when the guide shaft **113** axially rotates, ensuring that the projection **114** and the groove **214** can be kept stably engaged to each other. However, it is quite difficult or almost impossible to have a space in an electric connector recently attempted to be down-sized more and more for designing the projection **114** to have a greater height or designing the groove **214** to have a greater depth. If the projection **114** were designed to have a small height or the groove **214** were designed to have a small depth, since the housings **11** and **21** are made of resin and, therefore, have a small mechanical strength, the projection **114** would be readily collapsed, and further, could not prevent the axial rotation.

Since the contact planes S**0**, Sy and Sz illustrated in FIGS. **9**, **13** and **14**, respectively, are inclined relative to the contact plane Sx illustrated in FIG. **12** or relative to the imaginary line L**1**, even if the projections **114**, **114**y and **114**z were designed to be identical in height to one another, the contact planes Sy, Sz and S having a greater inclination in this order can be designed to have a greater contact area in this order.

The contact planes Sy, Sz and S**0** have a greater inclination in this order relative to the contact plane Sx extensive in parallel with the imaginary line L**1**. Since a divided force to cause the projections **114**, **114**y and **114**z to be released out of the grooves **214**, **214**y and **214**z, respectively, is smaller in this order, it is harder for the projections **114**, **114**y and **114**z to be released out of the grooves **214**, **214**y and **214**z, respectively, in an order of the contact planes Sy, Sz and S**0**.

As illustrated in FIG. **9**, assuming that the inclination angle of the contact plane S**0** is defined as an angle θ formed by the imaginary line L**2** indicative of the contact plane S**0** and the imaginary line L**3**, it is preferable that the angle θ is in the range of 10 to 30 degrees both inclusive. If the angle θ is smaller than 10 degrees, the projection **114** and the groove **214** are slightly engaged to each other through the contact plane S**0** (defined as a plane extensive from both the upper ends **114**p of the sidewall **114**a of the projection and the bottom **214**p of the sidewall **214**a of the groove **214** to both the lower ends **114**q of the sidewall **114**a of the projection **114** and an opening edge **214**q of the sidewall **214**a of the groove **214**), as illustrated in FIG. **11**, the projection **114** may be readily collapsed due to excessive force acting on the projection **114** in the direction X**1**.

If the angle θ is greater than 30 degrees, the projection **114** and the groove **214** can be firmly engaged to each other. However, the upper ends **114***p* of the sidewall **114***a* of the projection **114** and the opening edge **214***q* of the sidewall **214***a* of the groove **214** cannot be prevented from having a small thickness, resulting in that the projection **114** may be readily collapsed. Thus, the angle θ is preferably set in the range of 10 to 30 degrees both inclusive.

As illustrated in FIG. **9**, an angle formed by the contact plane **S0** and the top surface **114***b* of the projection **114** extending from the outermost end **P1** of the contact plane **S0** in a direction opposite to the direction **X1** is designed to be an acute angle, ensuring that the projection **114** can be firmly engaged to the groove **214**.

Furthermore, since the projection **114** is designed to have the arcuate top surface **114***b*, the projection **114** can have a greater thickness at the upper ends **114***p* of the sidewall **114***a* than the projection designed to have a flat top surface. In addition, the projection **114** can be entirely formed thick in the direction **X1**, ensuring that the projection **114** can have an increased strength.

Furthermore, the arcuate top surface **114***b* can be readily molded with resin.

As an alternative, the projection **114** may be designed to have a flat top surface, in which case, an amount of resin for molding the projection **114** can be reduced.

The electric connector in accordance with the first embodiment is designed to include the four projections **114** and the four grooves **214**. The projections **114** are arranged radially at every 90 degrees on an outer surface of the main body **113***a*. Similarly, the grooves **214** are arranged radially at every 90 degrees on an inner surface of the guide hole **213***a*. Thus, a stress acting on the groove **214** from the projection **114** when the projection **114** makes axial rotation can be uniformly dispersed. The number of the projections and the grooves is not to be limited to four. The electric connector may be designed to include two or more projections, and grooves in the same number as that of the projections. If the electric connector includes two, three or five projections and grooves, they are arranged at every 180, 120 or 72 degrees, respectively. That is, the projections and the grooves are circumferentially equally spaced away from adjacent ones, ensuring the same advantages as those provided by the four projections and the four grooves.

The guide shaft **113**, **113***x*, **113***y* and **113***z* illustrated in FIGS. **9** to **14** are designed to rotate in the direction **X1**, that is, in a clockwise direction. It should be noted that they may be designed to rotate in a counterclockwise direction.

In the first embodiment, the male connector **10** is designed to include the guide shaft **113**, and the female connector **20** is designed to include the shaft **213** formed with the guide hole **213***a* into which the guide shaft **113** is fit. As an alternative, the male connector **10** may be designed to include the shaft **213**, and the female connector **20** may be designed to include the guide shaft **113**.

The present invention is embodied in the electric connector including the male connector **10** and the female connector **20**. It should be noted that the present invention may be embodied in a general combination of a shaft and a hole into which the shaft is fit.

INDUSTRIAL APPLICABILITY

The electric connector in accordance with the present invention may be employed in various fields such as the electric/electronic industry and the automobile industry, as an electric connector to be used for electric/electronic devices or an electric connector to be equipped in an automobile. For instance, the electric connector in accordance with the present invention may be applied to a connector suitable for a glow plug, a connector for connecting a combustion pressure sensor with a wire harness, or a connector connecting cables to each other

While the present invention has been described in connection with certain preferred embodiments, it is to be understood that the subject matter encompassed by way of the present invention is not to be limited to those specific embodiments. On the contrary, it is intended for the subject matter of the invention to include all alternatives, modifications and equivalents as can be included within the spirit and scope of the following claims.

The entire disclosure of Japanese Patent Application No. 2013-210358 filed on Oct. 7, 2013 including specification, claims, drawings and summary is incorporated herein by reference in its entirety.

What is claimed is:

1. A combination of a shaft and a hole into which said shaft can be inserted,

wherein said shaft has a main body, and has a projection radially projecting from said main body,

wherein said hole has an inner surface, and said inner surface has a groove into which said projection is fit,

wherein said projection and said groove are formed such that:

a first imaginary line is defined by extending a contact plane at which said projection and said groove make contact with each other when said shaft rotates relative to said hole, towards a center of said shaft, and

a second imaginary line is defined as a line bisecting a top surface of said projection and extending towards said center of said shaft,

said first imaginary line intersects with said second imaginary line between said projection and said center of said shaft.

2. The combination as set forth in claim **1**, wherein said shaft includes a plurality of projections, and said hole is formed with a plurality of grooves, and

wherein said projections are equally spaced apart from each other, and said grooves are equally spaced apart from each other.

3. The combination as set forth in claim **1**, wherein said projection has an arcuate top surface.

4. The combination as set forth in claim **1**, wherein said projection is formed on an outer surface of said main body of said shaft, and said groove is formed in an inner surface of said hole.

5. An electric connector comprising:

a first housing including a guide shaft; and

a second housing including a guide hole into which said guide shaft is inserted,

wherein said guide shaft has a main body, and has a projection radially projecting from said main body,

wherein said guide hole has an inner surface, and said inner surface has a groove into which said projection is fit,

wherein said projection and said groove are formed such that:

a first imaginary line is defined by extending a contact plane at which said projection and said groove make contact with each other when said first housing rotates relative to said second housing, towards a center of said guide shaft,

a second imaginary line is defined as a line bisecting a top surface of said projection and extending towards said center of said guide shaft, and said first imaginary line intersects with said second imaginary line between said projection and said center of said guide shaft.

6. The electric connector as set forth in claim **1**, wherein said guide shaft includes a plurality of projections, and said guide hole is formed with a plurality of grooves, and

wherein said projections being equally spaced apart from each other, and said grooves being equally spaced apart from each other.

7. The electric connector as set forth in claim **1**, wherein said first housing comprises a housing of a male connector, and said second housing comprises a housing of a female connector,

wherein said guide shaft extends in said first housing, and wherein said guide hole is formed along an axis of a shaft extending in said second housing.

8. The electric connector as set forth in claim **5**, wherein said projection has an arcuate top surface.

9. The electric connector as set forth in claim **5**, wherein said first imaginary line and a third imaginary line connecting an outermost end of said projection and said center of said guide shaft with each other form an angle in a range of 10 degrees to 30 degrees both inclusive.

10. The electric connector as set forth in claim **1**, wherein said contact plane and said top surface of said projection form an acute angle.

11. The electric connector as set forth in claim **5**, wherein said projection is formed on an outer surface of said main body of said guide shaft, and said groove is formed in an inner surface of said guide hole.

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